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# Mark Scheme (Results)

## June 2019

Pearson Edexcel International Advanced Subsidiary Level
In Physics (WPH11)
Paper 01 Mechanics and Materials

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## General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

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**Mark scheme notes**

**Underlying principle**

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

For example:

(iii) Horizontal force of hinge on table top

| | | |
|---|---|---|
| 66.3 (N) or 66 (N) **and** correct indication of direction [no ue]<br>[Some examples of direction: acting from right (to left) / to the left / West / opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.] | ✓ | **1** |

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

1. **Mark scheme format**
   - 1.1 You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the ms has specified specific words that must be present. Such words will be indicated by underlining e.g. 'resonance'
   - 1.2 Bold lower case will be used for emphasis.
   - 1.3 Round brackets ( ) indicate words that are not essential e.g. "(hence) distance is increased".
   - 1.4 Square brackets [ ] indicate advice to examiners or examples e.g. [Do not accept gravity] [ecf].

2. **Unit error penalties**
   - 2.1 A separate mark is not usually given for a unit but a missing or incorrect unit will normally mean that the final calculation mark will not be awarded.
   - 2.2 Incorrect use of case e.g. 'Watt' or 'w' will **not** be penalised.
   - 2.3 There will be no unit penalty applied in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.
   - 2.4 The same missing or incorrect unit will not be penalised more than once within one question (one clip in epen).
   - 2.5 Occasionally, it may be decided not to penalise a missing or incorrect unit e.g. the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.
   - 2.6 The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

3. **Significant figures**
   - 3.1 Use of an inappropriate number of significant figures in the theory papers will normally only be penalised in 'show that' questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.
   - 3.2 The use of $g$ = 10 m $s^{-2}$ or 10 N $kg^{-1}$ instead of 9.81 m $s^{-2}$ or 9.81 N $kg^{-1}$ will be penalised by one mark (but not more than once per clip). Accept 9.8 m $s^{-2}$ or 9.8 N $kg^{-1}$

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**4. Calculations**

4.1 Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.

4.2 If a 'show that' question is worth 2 marks then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.

4.3 **use** of the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors e.g. power of 10 error.

4.4 **recall** of the correct formula will be awarded when the formula is seen or implied by substitution.

4.5 The mark scheme will show a correctly worked answer for illustration only.

4.6 Example of mark scheme for a calculation:

'Show that' calculation of weight

Use of L × W × H ✓

Substitution into density equation with a volume and density ✓

Correct answer [49.4 (N)] to at least 3 sig fig. [No ue] ✓
[If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark]
[Bald answer scores 0, reverse calculation 2/3] **3**

Example of answer:

80 cm × 50 cm × 1.8 cm = 7200 $cm^3$

7200 $cm^3$ × 0.70 g $cm^{-3}$ = 5040 g

5040 × $10^{-3}$ kg × 9.81 N/kg

= 49.4 N

**5. Quality of Written Communication**

5.1 Indicated by QoWC in mark scheme. QWC – Work must be clear and organised in a logical manner using technical wording where appropriate.

5.2 Usually it is part of a max mark, the final mark not being awarded unless the QoWC condition has been satisfied.

**6. Graphs**

6.1 A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.

6.2 Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.

6.3 A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale e.g. multiples of 3, 7 etc.

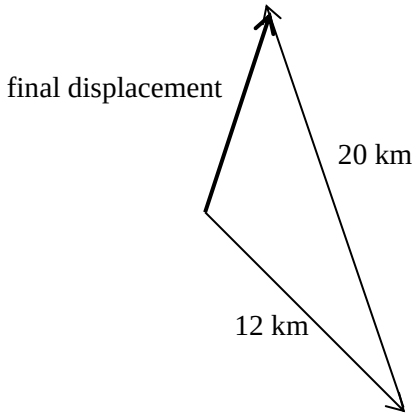
6.4 Points should be plotted to within 1 mm.

- Check the two points furthest from the best line. If both OK award mark.
- If either is 2 mm out do not award mark.
- If both are 1 mm out do not award mark.
- If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.
- For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

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| Question Number | Answer | Mark |
|---|---|---|
| **1** | **The only correct answer is D** because kg $m^{-3}$ is the unit for density (scalar)<br><br>**A** *is not the correct answer as m* $s^{-1}$ *is the unit for velocity (vector) and speed (scalar)*<br>**B** *is not the correct answer as m* $s^{-2}$ *is the unit for acceleration (vector)*<br>**C** *is not the correct answer as kg m* $s^{-2}$ *is the unit for force (vector)* | **(1)** |
| **2** | **The only correct answer is C** as the velocity is changing (due to the direction changing) and N2 describes a resultant force (due to the gravitational force of the earth) causing a change in velocity<br><br>**A** *is not the correct answer as the velocity is changing*<br>**B** *is not the correct answer as the velocity is changing and N2 describes a changing velocity due to unbalanced forces*<br>**D** *is not the correct answer as N2 describes a changing velocity due to unbalanced forces* | **(1)** |
| **3** | **The only correct answer is B** because<br>Upthrust is equal to weight of sphere (2.5 N).<br>Weight of displaced water if half sphere submerged = 2.5 N<br>Weight of displaced water if all of sphere submerged = 5.0 N<br>Total upwards force acting on sphere when completely submerged = 5.0 N<br>Total downwards force on sphere if completely submerged (and stationary) = 5.0 N<br>*F* must be equal to 2.5 N<br><br>**A** *is not the correct answer as F = 2.5 N*<br>**C** *is not the correct answer as F = 2.5 N*<br>**D** *is not the correct answer as F = 2.5 N* | **(1)** |
| **4** | **The only correct answer is B** as $s = vt$ and $s = 1.2 \times 0.9$<br><br>**A** *is not the correct answer as s = vt and s = 1.2 × 0.9*<br>**C** *is not the correct answer as s = vt and s = 1.2 × 0.9*<br>**D** *is not the correct answer as s = vt and s = 1.2 × 0.9* | **(1)** |
| **5** | **The only correct answer is D**<br><br>**A** *is not the correct answer as smaller particles of sand have a lower terminal velocity so take longer to reach the bottom of the beaker*<br>**B** *is not the correct answer as a lower temperature would increase the viscosity and increase the time taken for the particles to reach the bottom of the beaker (lower terminal velocity)*<br>**C** *is not the correct answer as the sand particles take longer to reach the bottom of the beaker with a smaller terminal velocity* | **(1)** |
| **6** | **The only correct answer is C**<br><br>**A** *is not the correct answer as it has a high elastic limit*<br>**B** *is not the correct answer as it has a high elastic limit and a small region of plastic deformation*<br>**D** *is not the correct answer as it has a small region of plastic deformation* | **(1)** |

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| | | |
|---|---|---|
| **7** | **The only correct answer is B** as power output = kinetic energy per second of the ejected water.<br>$P = \frac{\frac{1}{2} \times 0.2\ kg \times (3\ m\ s^{-1})^2}{1\ second} = \frac{0.2\ \times 3^{\ 2}}{2}$<br><br>**A** *is not the correct answer because the mass has not been converted into kg which is required for a power in watts.*<br>**C** *is not the correct answer because the mass is in g and the velocity has not been squared*<br>**D** *is not the correct answer because the velocity has not been squared* | **(1)** |
| **8** | **The only correct answer is C** as the acceleration is positive while the fuel is still burning. It then becomes negative, while still travelling upwards, as the only forces acting on it are downwards (weight and drag).<br><br>**A** *is not the correct answer because the acceleration should be constant as there is a constant upwards thrust from the fuel.*<br>**B** *is not the correct answer because the acceleration should be constant as there is a constant upwards thrust from the fuel. The acceleration should become negative before T.*<br>**D** *is not the correct answer because the acceleration becomes negative as the fuel runs out and not at the maximum height.* | **(1)** |
| **9** | **The only correct answer is B**<br><br><br>**A** *is not the correct answer as the length and direction of the line are incorrect*<br>**C** *is not the correct answer as the length and direction of the line are incorrect*<br>**B** *is not the correct answer as the length and direction of the line are incorrect* | **(1)** |
| **10** | **The only correct answer is C** because taking upwards as positive,<br>force of floor of lift on student – weight of student = mass × acceleration<br>$800 - 70g = 70a$<br><br>**A** *is not the correct answer because the force of the lift on the student was omitted and the direction of the weight is incorrect*<br>**B** *is not the correct answer because the weight of the student has been omitted*<br>**D** *is not the correct answer because the weight and the force of the lift on the student are in the wrong direction* | **(1)** |

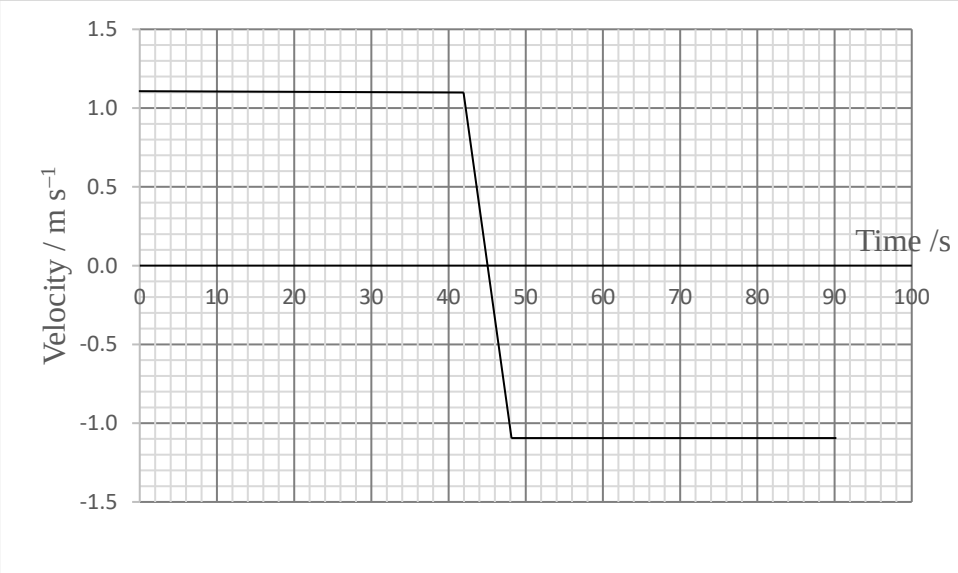
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| Question Number | Answer | Mark |
|---|---|---|
| **11** | **Max 4**<br>• Initial momentum (of the child, ball and skateboard/total) is zero (1)<br>• Due to conservation of momentum, the total momentum before the ball is thrown = total momentum after the ball is thrown (so final total momentum is zero) (1)<br>• The momentum of the child/skateboard is equal to the momentum of the ball (1)<br>• The momentum of the child/skateboard is opposite in direction to the momentum of the ball (1)<br>• As the mass of the child/skateboard greater (than the mass of ball), the velocity (of the child/skateboard) will be lower (1)<br>(all symbols to be defined, '*mv*' to be defined if used for momentum)<br>(MP3 accept to the right/positive for forwards) | **4** |
| | **Total for question 11** | **4** |

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| Question Number | Answer | | Mark |
|---|---|---|---|
| **12** | **Either** | (1) | **4** |
| | • Use of sin $\theta = \frac{2.0}{15}$ **Or** use of $\theta = 7.7\ °$ | (1) | |
| | • Use of Work done = $F\Delta s$ **Or** use of $E_{grav} = mg\Delta h$ | (1) | |
| | • Use of efficiency = $\frac{\text{useful energy output}}{\text{total energy input}}$ ($\times$ 100 %) | (1) | |
| | • Efficiency = 83 or 84 % so less than 90 %<br>(MP4 dependent on scoring all points MP1& 2 &3) | (1) | |
| | Example of calculation | (1) | |
| | $\sin^{-1}\left(\frac{2.0}{15}\right) = 7.7\ °$ | (1) | |
| | $W_{50} = 50\ \text{kg} \times 9.81\ \text{N kg}^{-1} \times 2.0\ \text{m} \times \frac{2.0}{15} = 130.8\ \text{J}$ | (1) | |
| | $W_8 = 8.0\ \text{kg} \times 9.81\ \text{N kg}^{-1} \times 2.0\ \text{m} = 157.0\ \text{J}$ | (1) | |
| | Efficiency = $\frac{130.8\ \text{J}}{157.0\ \text{J}} \times 100\ \% = 83\ \%$ | | |
| | **Total for question 12** | | **4** |

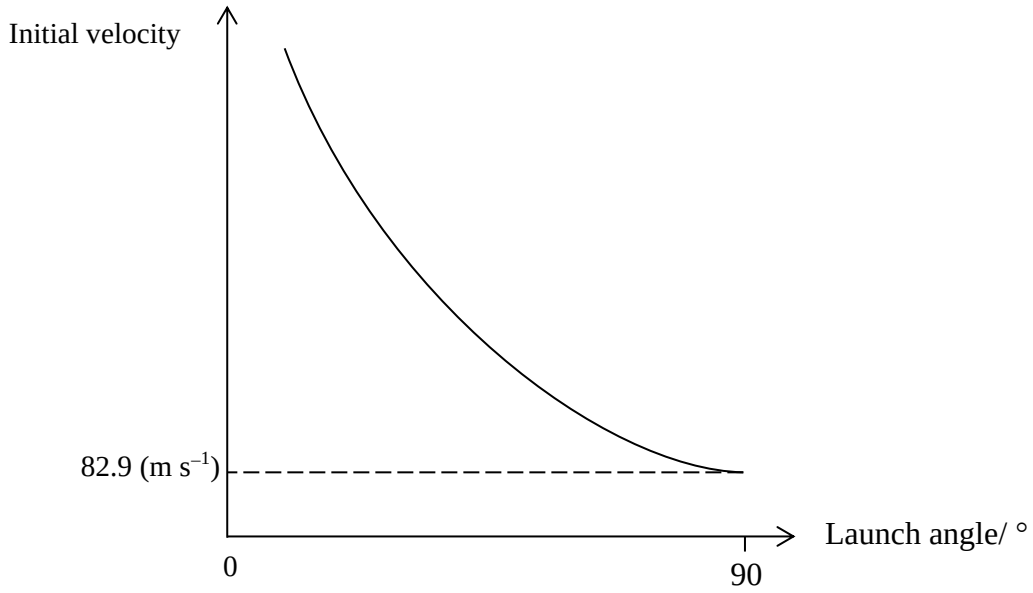
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| Question Number | Answer | | Mark |
|---|---|---|---|
| **13(a)** | • Use of $v = s/t$ **Or** use of gradient | (1) | |
| | • $v$ = (±) 1.1 to 1.2 (m s$^{-1}$) | (1) | |
| | • Scaling of the velocity axis so that the graph covers at least 50% of the paper above and below the axes.<br>(A minimum of 1 number on each axis required e.g. 1 and −1) | (1) | |
| | • A positive constant velocity from 0 to 42 s and the same negative constant velocity from 48 s to 90 s with connecting line/curve (tolerance of ± 1 s) | (1) | 4 |
| | <u>Example of calculation</u><br>Initial velocity = $\frac{46\text{ m}}{40\text{ s}}$ = 1.15 m s$^{-1}$ | | |
| |  | | |
| **13(b)(i)** | The graph should be a curve initially | (1) | |
| | with a decreasing gradient up to 15 m (by eye)<br>(ignore any part of the graph above 15 m) | (1) | 2 |

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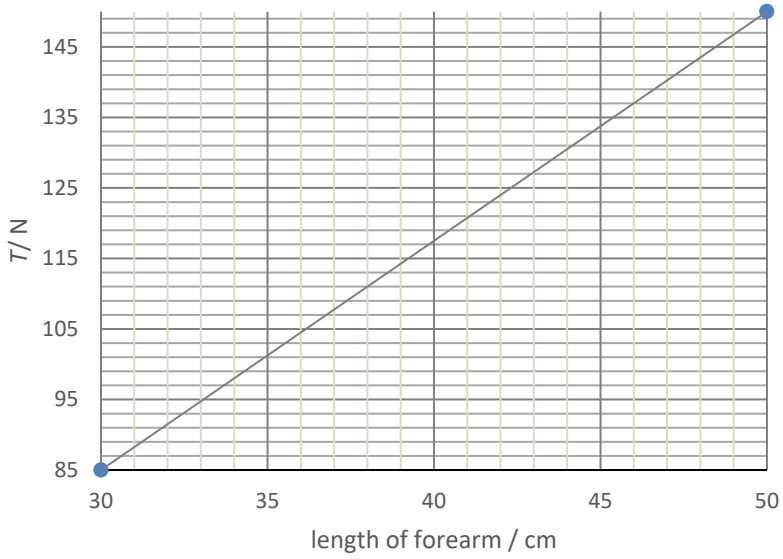
<table>
<tr>
<td>13(b)(ii)</td>
<td>1 mark for a simplification (1)<br><br>1 mark for a corresponding explanation (1)<br><br>
<table>
<tr><th>Simplification</th><th>Explanation</th></tr>
<tr><td>Velocity constant<br>Or velocity doesn’t change<br>Or velocity is an average<br>Or no regions of acceleration/deceleration</td><td>• Variation in velocity during each stroke<br>• The force applied to the swimmer/water varies (within the stroke)<br>• As the swimmer moves above/below water to breathe, the velocity changes<br>• The speed would change as they went from gliding to swimming</td></tr>
<tr><td>The velocity of the swimmer has the same magnitude in both parts of the race</td><td>The swimmer may have tired and this could be less for the second half of the race</td></tr>
<tr><td>The initial velocity after the turn would be greater</td><td>The swimmer would probably glide (underwater) after the turn</td></tr>
<tr><td>Gradient should initially increase from zero</td><td>Swimmer initially pushes off from starting block/turn</td></tr>
</table>
<br>Treat references to drag as neutral.</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Total for question 13</td>
<td>8</td>
</tr>
</table>

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| Question Number | Answer | Mark |
|---|---|---|
| **14(a)(i)** | • Use of equation(s) of motion to determine $u_v$<br>**Or** Use of $E_k = E_{grav}$ (1)<br>• $u_v = 83$ (m s$^{-1}$) (1)<br>(for mp2 must have used $v = 0$ and $-g$)<br><br>Example of calculation<br>$0^2 = u^2 + 2(-9.81 \text{ m s}^{-2})(350 \text{ m})$<br>$u = 82.9$ m s$^{-1}$ | **2** |
| **14(a)(ii)** | • Launch angle increasing as initial velocity decreases (i.e. negative gradient) (1)<br>• Curve drawn (1)<br>• Minimum initial velocity marked, and graph passes through (90, 82.9/80)<br>**Or** other correct pair of points labelled and plotted (1)<br>• Initial velocity axis asymptotic (1)<br><br><br> | **4** |
| **14(b)** | (Perpendicular) distance to firework= time (counted) × speed of sound (1)<br><br>Diameter of firework = 2 × distance × tan ($\phi$/2) (1)<br>(allow Diameter of firework = distance × tan ($\phi$/2)) | **2** |
| | **Total for question 14** | **8** |

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| Question Number | Answer | | Mark |
|---|---|---|---|
| **15(a)** | • Estimate of length of forearm 30 – 50 (cm) | (1) | **5** |
| | • Use of trig to determine the perpendicular component of the tension<br>**Or** see *T*sin70 **Or** see *T*cos20 | (1) | |
| | • Use of moment = *Fx* with a corresponding force and distance | (1) | |
| | • Use of the principle of moments | (1) | |
| | • Value for *T* in range 85 N to 150 N<br>(*l* = 30 cm, *T* = 85 N and *l* = 50 cm, *T* = 150 N) | (1) | |
| | <u>Example of calculation</u> (for *l* = 0.40 m)<br>(0.04 m × *T* × sin70) = (0.31 m × 4.5 N) + (0.20 m × 15 N)<br>*T* = 117 N | | |
| **15(b)** | • The forearm is not uniform/symmetrical | (1) | **2** |
| | • The centre of gravity is not in the middle | (1) | |
| | **Total for question 15** | | **7** |



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| Question Number | Answer | Mark |
|---|---|---|
| **16(a)** | • Use a micrometer (screw gauge) **Or** (vernier)digital calipers (1)<br>• At different orientations **and/or** positions along the wire (1)<br>• Calculate/determine/take/find a mean/average value (1) | **3** |
| **16(b)** | • Use of $A = \pi\left(\frac{d}{2}\right)^2$ (1)<br>• Calculate gradient of linear section (up to $3 \times 10^{-3}$ m, 6.8 N) of graph **Or** use of a corresponding pair of points for $F$ and $\Delta x$ from the linear region of the graph (1)<br>• Use of $\sigma = \frac{F}{A}$ and $\varepsilon = \frac{\Delta x}{l}$ **Or** use of $E = \frac{Fl}{A\Delta x}$ **Or** Use of $E =$ gradient $\times \frac{l}{A}$ (1)<br>• $E = (1.2 – 1.3) \times 10^{11}$ Pa (1)<br>(MP4 conditional on scoring MP1 & MP2 & MP3)<br><br><u>Example of calculation using gradient</u><br>$A = \pi\left(\frac{2.3 \times 10^{-4}\text{ m}}{2}\right)^2 = 4.15 \times 10^{-8}$ m$^2$<br>Gradient $= \frac{6.5\text{ N}}{2.9 \times 10^{-3}\text{ m}} = 2.2 \times 10^3$ N m$^{-1}$<br>$E = 2.2 \times 10^3$ N m$^{-1} \times \frac{2.4\text{ m}}{4.15 \times 10^{-8}\text{m}^2} = 1.27 \times 10^{11}$ Pa | **4** |

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***16(c)**

- This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.
- Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.
- The following table shows how the marks should be awarded for indicative content.

| Number of indicative marking points seen in answer | Number of marks awarded for indicative marking points |
|---|---|
| 6 | 4 |
| 5–4 | 3 |
| 3–2 | 2 |
| 1 | 1 |
| 0 | 0 |

- The following table shows how the marks should be awarded for structure and lines of reasoning.

| | Number of marks awarded for structure of answer and sustained line of reasoning |
|---|---|
| Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout | 2<br>(a minimum of at least 5 IC points including:<br>IC1 and IC2/IC5<br>**and** IC3 and IC4/IC5 |
| Answer is partially structured with some linkages and lines of reasoning | 1<br>(a minimum of 3 IC points including:<br>**either** IC1 and IC2/IC5<br>**Or** IC3 and IC4/IC5) |
| Answer has no linkages between points and is unstructured | 0 |

Total marks awarded is the sum of marks for indicative content and the marks for structure and lines of reasoning

**Indicative content**

- For long(er) wire, the extension will be large(r)
- (For the same load) extension is proportional to the original length

  **Or** $\frac{\text{extension}}{\text{original length}} = \text{constant}$
- For a thin(ner) wire, the extension will be large(r)
- (For the same load) extension is inversely proportional to cross-sectional area (may be explained in terms of $E$, $\sigma$ and $\varepsilon$)
- The percentage uncertainty in the extension/length will be lower (although this will be greater for the cross-sectional area)
- A small(er) load can be used with a long/thin wire

**6**

**Total for question 16** **13**

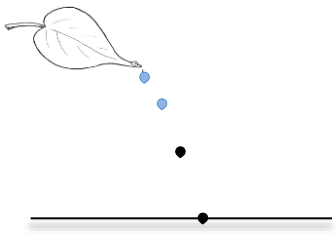
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| Question Number | Answer | Mark |
|---|---|---|
| **17(a)(i)** | Use of fall factor = $\frac{\text{height fallen before the rope begins to stretch}}{\text{total unstretched length of rope}}$ **(1)**<br><br>Use of $\varepsilon = \frac{\Delta x}{x}$ with $x$ = 15.0 m **(1)**<br><br>Use of $E_{grav} = mg\Delta h$ **(1)**<br><br>Use of $E_{grav} = E_{el}$ with their $\Delta x$ **(1)**<br><br>$F_{max}$ = 14 000 (N) **(1)**<br><br><u>Example of calculation</u><br>Height fallen = 15.0 m × 0.8 = 12 m  $\Delta x$ = 0.09 × 15.0 m = 1.35 m<br>$E_{grav}$ = 71 kg × 9.81 N kg$^{-1}$× 12 m = 8358 J (from fall)<br>$E_{grav}$ = 71 kg × 9.81 N kg$^{-1}$× 1.35 m = 940.3 J (from extension)<br>8358 J + 940.3 J = ½ × $F_{max}$ × 1.35 m<br>$F_{max}$ = 13 775 N | **5** |
| **17(a)(ii)** | • This would not be a good idea, as the climber would reach a higher velocity (just before the rope stretches) **(1)**<br>• (Hence) the climber's deceleration/force (as the rope stretches) would be greater **(1)** | **2** |
| **17(b)** | **Max 6**<br>• Use of area under the graph to determine the stored energy **(1)**<br><br>• Energy = 800 J (new) **(1)**<br><br>• Energy = 700 J (old) **(1)**<br><br>• The old rope would absorb/store less energy **(1)**<br><br>• Use of $F = k\Delta x$ to determine $k$ (accept gradient of a tangent) **(1)**<br><br>• Calculation of $k$ for both ropes at same applied force **(1)**<br><br>• The old rope is not as stiff as the new rope **(1)**<br>**Or** The old rope extends more **(1)**<br><br>• The old rope would break at a smaller applied force/stress | **6** |
| | **Total for question 17** | **13** |

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| Question Number | Answer | Mark |
|---|---|---|
| **18(a)(i)** | Explanation<br>• Terminal velocity is the constant/maximum velocity the rain reaches<br>**Or** terminal velocity is the velocity when acceleration = 0 (1)<br>• When weight = Drag (+ upthrust)<br>**Or** when forces is equilibrium<br>**Or** when resultant force = 0<br>(accept when the total upward force = total downward force) (1)<br><br>Diagram<br>• Weight and air resistance (and upthrust) only drawn with correct directions (arrowed lines must touch dot, and labels included) (1)<br>• Arrow lengths of weight and air resistance same length<br>(if upthrust drawn, upthrust line + drag line = weight line)<br>(MP4 dependent on MP3) (1)<br><br>Air resistance/*F*/*D*<br><br>Weight/*W*/*mg* | **4** |

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| | | | |
|---|---|---|---|
| **18(a)(ii)** | • Use of $A = \pi r^2$ **and** $V = \frac{4}{3}\pi r^3$ | (1) | **4** |
| | • Use of $\rho = \frac{m}{V}$ **and** $W = mg$ | (1) | |
| | • Use of $W = F$ | (1) | |
| | • $v$ = 6.5 – 7.0 m s$^{-1}$ | (1) | |
| | Example of calculation<br>$A = \pi \times (0.002)^2 = 1.26 \times 10^{-5}$ m$^2$<br>$V = \frac{4}{3}\pi \times (0.002 \text{ m})^3 = 3.35 \times 10^{-8}$ m$^3$<br>$m$ =1000 kg m$^{-3}$ × 3.35 × 10$^{-8}$ m$^3$ = 3.35 × 10$^{-5}$ kg<br>$W$ = 3.35 × 10$^{-5}$ kg × 9.81 N kg$^{-1}$ = 3.29 × 10$^{-4}$ N<br>3.29 × 10$^{-4}$ N = 0. 45 × 1.2 kg m$^{-3}$ × 1.26 × 10$^{-5}$ m$^2$ × $v^2$<br>3.29 × 10$^{-4}$ N = 6.80 × 10$^{-6}$ × $v^2$<br>$v$ = 6.96 m s$^{-1}$ | | |
| **18(b)(i)** | • Vertical displacement increasing | (1) | **2** |
| | • Horizontal displacement constant (same as first two drops) | (1) | |
| | (Mark all added drops but there must be a minimum of 2 additional drops to award MP1 &2)<br> | | |
| **18(b)(ii)** | • Use of $s = ut + \frac{1}{2}at^2$ with $u = 0$<br>(accept use of t = 0.2 s, 0.25 s, 0.75 s, 1.0 s) | (1) | **3** |
| | • See 0.8 s for the time since the drop left the leaf | (1) | |
| | • $s$ = 3.1 m | (1) | |
| | Example of calculation<br>$s$ = ½ ×9.81 N kg$^{-1}$× (0.8 s)$^2$ = 3.14 m | | |
| | **Total for question 18** | | **13** |